IOWA CONSERVATION COMMISSION

FISHERIES SECTION

FEDERAL AID TO FISH RESTORATION

ANNUAL PERFORMANCE REPORT

MAN-MADE LAKE INVESTIGATIONS

PROJECT NO. F-88-R-1

Study No. 504-1 - Evaluation of Biological Control of Nuisance Aquatic Vegetation by White Amur, *Ctenopharyngodon idella*, (Valenciennes)

Job 1. Production of Aquatic Vegetation Prior to Release of White Amur
Job 2. Production of Aquatic Vegetation After Introduction of White Amur
Job 3. Life History Studies of White Amur
Job 4. Population Dynamics of White Amur

Period Covered: 1 July, 1973 to 30 June, 1974

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ANNUAL PERFORMANCE REPORT

RESEARCH PROJECT SEGMENT

STATE: Iowa

PROJECT NO.: F-88-R-1

STUDY NO.: 504-1

JOB NOS.: 1, 2, 3, & 4

NAME: Evaluation of Biological Control of Nuisance Aquatic Vegetation by White Amur, *Ctenopharyngodon idella* (Valenciennes)

TITLE: Job 1 - Production of aquatic vegetation prior to release of white amur

Job 2 - Production of aquatic vegetation after introduction of white amur

Job 3 - Life history studies of white amur

Job 4 - Population dynamics of white amur

Period Covered: 1 July, 1973 through 30 June, 1974

ABSTRACT: Five hundred thirty white amur were stocked at Red Haw Lake, a 29 ha impoundment in southern Iowa, to evaluate their effectiveness on control of undesirable aquatic vegetation. Mean length and weight of the fish at release was 310 mm at 380 g. Standing crop of vegetation prior to introduction on 18 July was 76 metric tons. One month later vegetation biomass declined to 19 metric tons. White amur fed exclusively on macrophytes and Potomogeton was the most numerous food item in the alimentary tract, however, Ceratophyllum was most preferred. Growth was rapid and in 78 days the population standing stock increased by fivefold. Mortality from known causes was 3% during July-December. White amur consumed 37 metric tons of vegetation and controlled 50% of the July macrophyte standing crop. Relationship of plant production and biological control were discussed.

Author: Larry Mitzner
Fisheries Biologist

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Approved by: James Mayhew
Fisheries Research Supervisor

Date approved: 1 September, 1974

STUDY OBJECTIVE

Evaluate the effectiveness of white amur as a biological controller of nuisance and undesirable aquatic vegetation in a small impoundment to increase

1. *primary productivity of phytoplankton*
2. *harvest of sport fish*
3. *maximize utilization of forage fish species by predators.*

JOB 1 OBJECTIVE

To estimate quantitative production and standing crop of aquatic vegetation prior to the white amur release.

JOB 2 OBJECTIVE

To estimate quantitative production and standing crop of aquatic vegetation after release of white amur.

JOB 3 OBJECTIVE

To determine food habits, growth and condition of white amur.

JOB 4 OBJECTIVE

To determine sources and extent of mortality of white amur.

INTRODUCTION AND STUDY BACKGROUND

High fertility and clear water in many Iowa man-made impoundments provide excellent growing conditions for rooted aquatic vegetation. Extensive communities of these plants in the littoral zone are undesirable to fishermen and detrimental to sport fish populations in several ways. First, shore fishing is severely limited by vegetation resulting in low harvest. Second, macrophytes are not used by fish or fish food organisms as food items. Third, greater fish production is attained if nutrients utilized by macrophytes were available to phytoplankton and primary consumers. Last, predator fish species do not effectively utilize small panfish for food when there is extensive and dense vegetative cover because forage fish escape.

These combined factors contribute to an unstable predator-prey relationship resulting in abundant, slow growing panfish populations. Management of these lakes by attempting to manipulate predator and prey populations is difficult and yearly efforts are usually required. Vegetation control is an important part of treating the problem, but mechanical or chemical control is expensive and not entirely effective.

White amur have been used to effectively control most species of vascular aquatic vegetation in small ponds. Since 1962, all quantitative evaluations of biological vegetation control by white amur have been in small culture ponds or aquaria, and there is a need for quantitative, critical evaluation of the effort of this species on macrophytes in larger bodies of water with vegetation problems.

White amur is an exotic species to this continent and it is imperative to determine what impact the introduction has on native species in a man-made impoundment. Literature reviews by Avault (1965), Swingle (1964) and McLeod (1972) showed white amur had great potential as an effective species to control aquatic vegetation and yet, because of its specific reproductive habits amur would not become a nuisance themselves by spreading through natural reproduction.

The primary objective of this study was to evaluate the white amur for biological control of undesirable vegetation control in Red Haw Lake, a 29 ha man-made impoundment. Supportive objectives were to estimate quantitative production and standing crop of vegetation before and after release of white amur and also determine their food habits, body condition, growth, and mortality rates.

DESCRIPTION OF STUDY AREA

Red Haw Lake is a 29 ha man-made impoundment near Chariton, Iowa, Lucas County. The earthen dam was completed in 1936 forming a "Y" shaped lake with many small embayments surrounded by a steep-sided valley with mature oak-hickory timber. Maximum depth is 12.2 m with mean depth of 4.5 m. Bottom slope is steep ranging from 3.6% to 18.6% with a mean slope of 8.6%. Severe thermal stratification occurred annually from May-September. Thermocline depth was usually at 3 m with the metalimnion not greater than 2 m deep.

Lake area to watershed area ratio was 1:25 with most of the watershed non-tillable. Sedimentary turbidity was low except during periods of extremely heavy runoff. Increased turbidity occurred periodically from plankton blooms. Rooted aquatic vegetation was abundant from mid-May through September forming a continuous aquatic macrophyte community around the entire shoreline, extending 10-20 m outward.

Bluegill, crappie and largemouth bass comprised the major part of fish standing stock in the lake. The remaining species complex included warmouth, green sunfish, yellow perch, golden shiner, channel catfish, bullhead, and carp. Channel catfish and carp populations were extremely low.

METHODS AND PROCEDURES

The approach for evaluating biological control of aquatic vegetation by white amur involved four steps. First, standing crop estimates and the extent of aquatic vegetation cover were determined to quantify vegetation levels. Second, white amur were introduced into the lake. Third, standing crop estimates of vegetation continued to determine the effect of white amur on the plant community. Fourth, life history and population dynamics of white amur were determined in relation to the effectiveness of biological vegetation control.

Standing crop estimates of macrophytes started on 13 July. Standing crop and species composition was estimated by an identical systematic procedure on each sampling date. First, the plant community was completely mapped. Depths at the outer edge of plant growth were plotted on a contour map. Sixty soundings were made at approximately 180 m intervals along the shore. In small embayments or near areas where vegetation growth was not uniform recordings were made at 50 m intervals. Points on the contour map were connected to encompass the area and extent of plant growth. Area of the plant community was then determined from the map with a planimeter.

Total biomass was estimated from the product of total plant community area in m^2 and the plant weight in random plot samples in kg/m^2. Sample plots were located in the littoral zone which was divided into 68 segments each approximately 65 m long. Ten permanent sample plots were randomly chosen from these segments. At each station a steel rod was placed in the substrate and marked with a bouy (Figure 1).

Samples were collected by two divers equipped with SCUBA using a vegometer, a frame enclosure 38 mm deep and .5 m on each side, covering an area of .25 m^2.

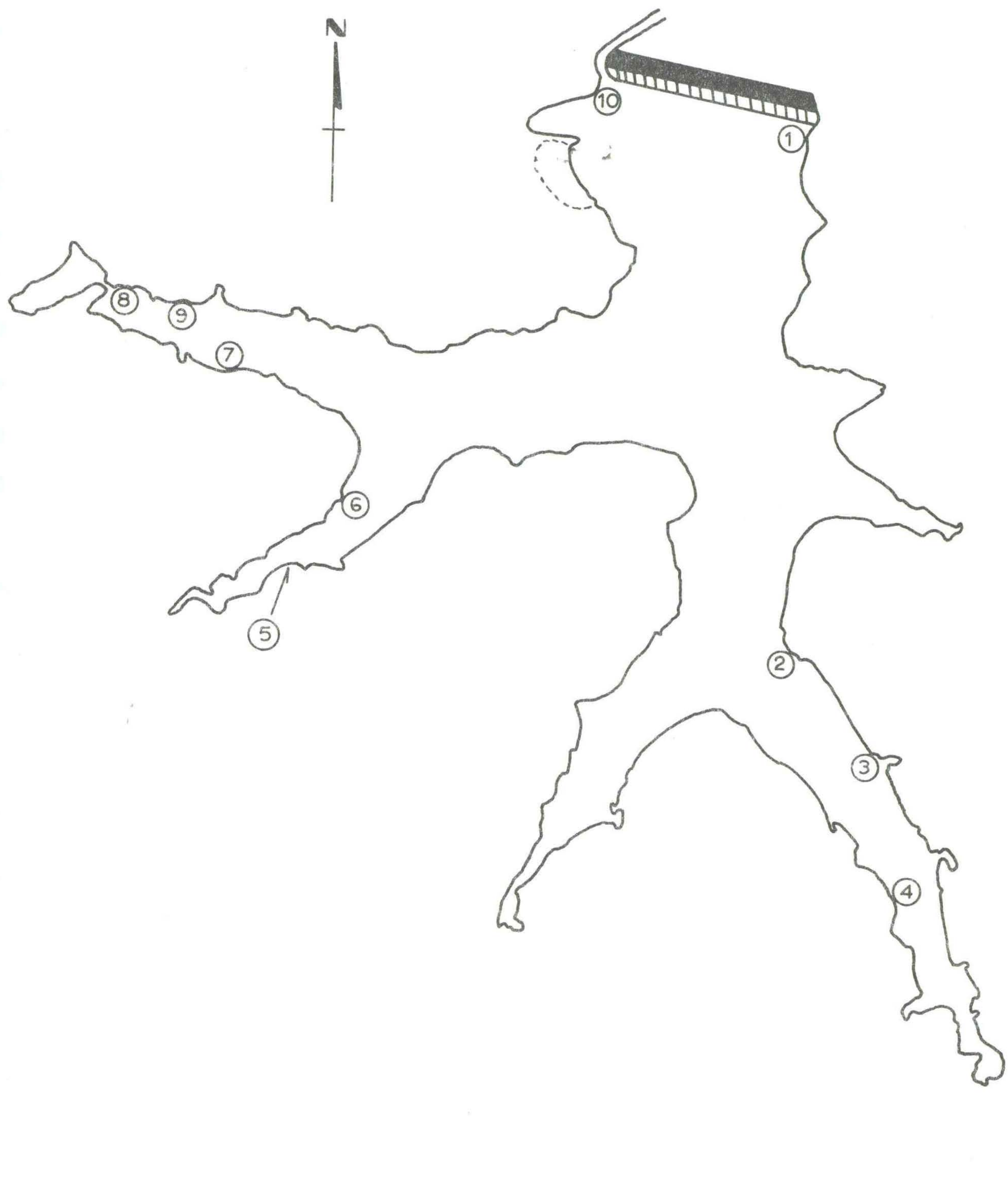

Figure 1. Vegetation sample plots at Red Haw Lake.

The divers placed the vegometer over the steel rod with the rod at the lower left corner as the divers faced the shoreline. The area was designated as "A". Replicate samples "B" were taken at each station with the rod in the upper right corner of the vegometer.

The vegometer was held on the substrate by the divers while they hand picked all vegetation within the plot. Excess moisture was immediately squeezed from the plants after the divers placed the sample in a boat. Samples were weighed and preserved in 6% formalin for identification in the laboratory.

Fassett (1966) was used to identify preserved specimens. Samples contained *Elodea occidentalis*, *Ceratophylum demersum*, *Najas flexilis* and *Potamogeton spp.* Many specimens of *Potamogeton* in the samples were unidentifiable to species because they lacked fruits, and *Potamogetons* were combined. Samples were sorted, identified and wet weights recorded for each taxonomic group.

Food habits, growth, body condition and sources and extent of mortality were determined for white amur in relation to the effectiveness of controlling aquatic vegetation.

Food consumption was determined by measuring the volume in the alimentary tract, identifying the contents and enumerating the occurrence for each food item in the tract. The whole alimentary tract was used because there was no differentiated stomach. The length of the tract was measured and divided in four equal lengths. The contents of each portion were placed in a graduated cylinder and allowed to settle for one hour. Contents were diluted 1:10 and agitated until the solution was homogeneous. Several drops from each gut portion were placed on a slide and the material cleared and fixed with chlorolhydrate and gum arabic solutions.

Reference slides were made of common plant species by crushing the material and preparing slides using the same method for stomach contents. Plant material in the alimentary tract was identified by comparing cellular size and structure with reference plant material. Three slides were prepared for each of four portions of the alimentary tract and two microscope fields were examined on each slide. Thus, 24 fields were used for each amur.

Food preference were determined by Ivlev's equation

$$EI = \frac{R_i - P_i}{R_i + P_i}$$

where R_i was the percent occurrence of the i^{th} food item in the stomach, P_i was the percent occurrence of the same food item in the macrophyte sample and EI was the electivity index.

Growth and body condition were determined monthly by measuring total body length and weight of white amur. All amur were weighed, measured and identified with a numbered dart-type tag when they were stocked. Growth and body condition were computed for individual fish from July-October by comparing vital statistics at release and recapture.

FINDINGS

VEGETATION DISTRIBUTION AND BIOMASS

Mapping of vegetation prior to white amur introduction was completed on 13 July, 1973. Depth at the outer perimeter of vegetation ranged from .6-1.5 m with a mean of 1.1 m. Plant growth was present along the entire shoreline except at the face of the dam and swimming area. These areas accounted for about 5% of the shoreline. The area covered by plant growth was 3.33 ha.

Vegetation samples from the station plots varied in weight from 50 g at Station 1 to 1,166 g at Station 2 (Table 1). Overall mean weight was 570 g.

Table 1. Wet weight in grams of rooted aquatic vegetation in sample plots at Red Haw Lake, 1973.

	19 July		21 August	
Station	A	B	A	B
1	50	358	9	4
2	1,166	1,039	168	177
3	376	794	236	209
4	594	626	141	113
5	567	826	77	68
6	472	372	141	82
7	277	1,048	204	268
8	903	381	372	318
9	445	572	367	132
10	435	95	141	136

Mean weight of replicates A was 529 g, while mean weight of B was 611 g. One standard deviation from the mean was ± 251 g and 95% confidence for the samples was ± 179 g. Analysis of variance showed the difference in replicate means was not significant ($p > .05$), but station means were significantly different ($p < .05$).

Mean weight of sample plots was expanded to the entire area of plant growth. Standing stock was estimated at 2.28 kg/m^2 over an area of 3.33 ha, yielding a total wet weight of plant tissue available for consumption by white amur at 76 metric tons (MT).

Potamogeton spp. was the major group of plants contributing 56.7% by weight to the samples. *Najas flexilis* followed in importance with 31.5% and in order by *Elodea occidentalis*, 3.1% and *Ceratophylum demersum*, 6.7%. Species occurrence at individual stations showed the plant community was more homogeneously distributed than species composition indicated. For instance, all samples contained *Potamogeton*, and *Najas*, while *Elodea* occurred in 71% of the samples. *Ceratophylum* was found in 14% of the samples.

Five hundred thirty age I white amur were stocked at Red Haw Lake on 24 July, 1973. Mean length of the fish was 310 mm and ranged from 255 mm to 490 mm. Mean weight was 380 g and ranged from 191 g to 1,210 g. Total weight of the population at introduction was 202 kg.

One month after the stocking of white amur the vegetated area declined from 3.33 to 2.94 ha. Plant biomass within the sample plots also decreased. Wet weights varied from 4 g at Station 1 to 372 at Station 8 (Table 1). Overall mean was 168 g with 95% confidence of ± 70 g. The reduction was probably due to two reasons. First, a direct reduction of vegetative area and second, reduced plant density within the littoral zone. Total plant biomass was 19 MT.

Results of analysis of variance were identical to the July samples; no difference between replicates, but a significant difference between stations. Comparison of July and August standing stock values by the same method showed vegetation biomass declined significantly after white amur were stocked.

Species composition of plant populations changed from the 19 July sample. *Najas* became most important and contributed 56.5% to the biomass, while *Potamogeton* contributed 36.5%. *Elodea* and *Ceratophyllum* were less common with 6.1% and .7%, respectively. Each species was widespread in the lake. *Potamogeton* and *Najas* were found at all stations. *Elodea* was found in 73% of the samples, while *Ceratophyllum* was found in 36% of the samples.

FOOD HABITS OF WHITE AMUR

Ten alimentary tracts were taken from 31 July to 11 October for analysis of food consumption. Length of the fish ranged from 348-520 mm with a mean of 452 mm. Mean weight was 1,400 g and ranged from 690-2,041 g. Length of the alimentary tract was approximately twice as long as body length. Volume of the contents ranged from 0-277 ml with a mean of 90 ml. Three tracts were empty, except for small traces of vegetation.

Vascular plants were by far the most important food item consumed by white amur. Strands of filamentous algae were present, but rare and the remains of one insect was observed.

Potamogeton was the most frequently consumed plant, comprising 65.7% of the samples. *Elodea* was second in importance and contributed 24% to the ration, while *Najas* and *Ceratophyllum* each contributed 7.1% and 3% (Table 2). All alimentary tracts contained *Potamogeton* and *Elodea*, while *Najas* was found in 86% of the samples and 71% contained *Ceratophyllum*.

Table 2. Percent composition of plant material in white amur alimentary tracts at Red Haw Lake.

White amur number	*Potamogeton*	*Elodea*	*Najas*	*Ceratophyllum*
69	35.9	50.5	13.4	0
163	58.0	30.4	8.7	2.9
218	62.0	12.0	14.0	12.0
270	88.6	9.5	0	1.7
468	64.7	26.4	5.8	2.9
473	76.0	20.0	4.0	0
491	74.4	19.5	3.7	2.4
Mean	65.7	24.0	7.1	3.1

Food preference based on Ivlev's electivity index showed *Ceratophyllum* was the most preferred food item, with a value of +.61 (Table 3). *Elodea* and *Potamogeton* had indices of +.52 and +.27. The electivity index for *Najas* was -.79.

Table 3. Electivity indices of white amur at Red Haw Lake.

White amur number	*Potamogeton*	*Elodea*	*Najas*	*Ceratophyllum*
69	-.01	.78	- .62	-1.00
163	.23	.64	- .73	.60
218	.26	.33	- .60	.89
270	.42	.22	-1.00	.42
468	.28	.62	- .81	.61
473	.35	.53	- .87	-1.00
491	.34	.52	- .88	.54
Mean	.27	.52	- .79	.61

GROWTH AND CONDITION OF WHITE AMUR

Body length and weight of white amur increased rapidly after they were stocked. Twenty-one fish were weighed and measured 7-79 days after release. Maximum growth was 232 mm in 78 days, while minimum growth was 167 mm in 78 days. Mean growth was approximately 2.5 mm per day from 24 July-12 October (Table 4). Mean weight of the recaptured fish at stocking was 339 g, but by 12 October mean weight increased to 1,817 g for a daily gain of 19 g. Daily growth in weight ranged from 6.4 to 32 g. Maximum growth was 32 g per day. In the 78 days standing stock increased over fivefold.

Condition factor also increased after release. On 24 July the K value was 1.15 with a range of 1.02-1.34. At the end of the sampling interval mean K was 1.45 and ranged from 1.38-1.54.

VEGETATION CONTROL

Standing crop of aquatic vegetation declined from 76 MT on 18 July to 19 MT on 21 August. A natural decrease in aquatic macrophytes was normal during this period at Red Haw so the entire loss in vegetation was not attributed to white

Table 4. Initial length (L_0) and weight (W_0) compared with length (L_T) and weight (W_T) after 7-79 days (T) of growth. Condition factors before release and at recapture were K_0 and K_T. Values are mm and g.

Fish number	L_0	L_T	L_Δ	W_0	W_T	W_Δ	K_0	K_T	T	W_Δ/day
35	299	482	183	358	1,551	1,193	1.34	1.39	79	15.1
59	290	470	180	249	1,579	1,330	1.02	1.52	78	17.1
75	290	485	195	295	1,579	1,285	1.21	1.38	78	16.5
80	310	509	199	318	1,900	1,582	1.07	1.44	78	20.3
104	323	516	193	376	1,960	1,584	1.12	1.43	78	20.3
121	290	488	198	281	1,778	1,497	1.15	1.53	78	19.2
163	275	419	144	240	1,310	1,070	1.15	1.78	43	24.9
166	293	460	167	286	1,284	998	1.14	1.32	78	12.8
218	271	465	194	204	1,497	1,293	1.02	1.49	76	17.0
270	328	520	192	399	2,041	1,642	1.13	1.45	77	21.3
281	312	495	183	376	1,873	1,497	1.24	1.54	78	19.2
283	342	352	10	426	626	200	1.06	1.44	7	20.0
338	330	503	173	417	1,914	1,497	1.16	1.60	77	19.4
415	296	481	186	318	1,579	1,261	1.24	1.41	78	16.2
468	298	495	197	322	1,642	1,320	1.22	1.35	78	16.9
470	300	532	232	290	2,227	1,937	1.07	1.48	78	24.8
473	314	374	6	349	626	277	1.13	1.20	43	6.4
476	330	522	192	386	1,910	1,524	1.07	1.34	78	19.5
486	310	502	192	349	1,746	1,397	1.17	1.38	78	17.9
491	340	348	8	463	689	226	1.18	1.63	7	32.3
541	331	501	170	422	1,683	1,261	1.16	1.34	79	16.0
Mean	308	472	164	339	1,571	1,232	1.15	1.45		18.7

amur. Undoubtedly, part of the reduction in vegetation biomass was caused from the consumption of macrophytes. Vegetation consumption was estimated by multiplying the increase in white amur standing crop by their food conversion ratio. White amur increased from 202 kg at stocking to 963 kg on 12 October for a net gain in biomass of 761 kg. Hickling (1966) described the increase in body weight to weight of food consumed as 1:48. Consequently, white amur consumed 37 MT of vegetation during the growing period.

WHITE AMUR MORTALITY

The shoreline was searched regularly after amur were stocked to estimate mortality indirectly caused by transport, handling and stocking. Several days after stocking one fish was found dead near the stocking site, but it was the only observed mortality. Fourteen fish were lost by netting and food habit studies. One amur was caught by a fisherman and released. When all known sources of mortality were considered a minimum of 15 fish were removed from the population by 31 December.

DISCUSSION OF FINDINGS

Three main factors affected the standing stock of vegetation at Red Haw Lake during the study segment. First, vegetation biomass increased in May and June when maximum growth and production occurred. Second, from mid-July through October biomass decreased by natural atrophy and decomposition. Last, there was consumption by white amur.

Evaluation of biological control of vegetation by white amur stocked at 7 kg/ha showed there was partial control during the study. Amur fed exclusively on aquatic macrophytes. More important, mortality was low, growth rapid and they consumed large quantities of vegetation.

Vegetation biomass was reduced by 57 MT after 18 July. During that period white amur consumed 37 MT. Production decreased after July and natural decay started, so amur were responsible for reducing the vegetation in the later part of the summer by a maximum of 50%.

Control of macrophytes during maximum vegetation production would be much less because regrowth would continue. Additional consumption would be needed during the peak growing season so production would be exceeded by consumption.

RECOMMENDATIONS

Additional white amur should be stocked to control aquatic vegetation during the peak production period in May and June. With a high amur population and more intensive control of vegetation the nutrient cycle at Red Haw may be elevated to a level which would cause heavy algal blooms. Particularly, phosphorous might be shunted directly from macrophyte tissue to phytoplankton. Nutrient content of the water and primary production should be monitored monthly in the next study segments to determine the relationship of vegetation control, nutrients and primary production.

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